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Attitudes and Metacognitive Awareness as Predictors of Undergraduates' Algebra Scores

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Abstract

Research examining students' attitudes and awareness of how to learn mathematics and their effect on performance is still inconclusive. The study examined the relationship among first year students' attitudes towards learning algebra, metacognitive awareness and algebra performance at a university in Ghana. Two inventories were adopted and used to collect data from an intact class of 180 first year mathematics education students. These students' end of semester examination scores in first year algebra were used to indicate their performance in algebra. Data was analysed using descriptive statistics, correlation and linear regression analysis at .05 significance level. On the four subscales of attitude, the result shows significantly weak negative relationships between students' self-confidence and algebra scores, as well as students' enjoyment for algebra and algebra scores. Also, there was significant positive relationship between students' metacognitive awareness in algebra and algebra scores. However, students' value of algebra and motivation were not statistically related to their algebra scores. The regression analysis indicated that students' attitude towards the learning of algebra (self-confidence and enjoyment) and metacognitive awareness levels predicted students' scores in algebra. The findings suggest the need for algebra lecturers to enhance first year students' metacognitive skills and positive attitudes as bases for boosting performance in algebra. The implication, for lecturers providing orientation to first year students on how to learn to think algebraically in their first lecture, is highlighted.

Keywords: attitudes towards mathematics; metacognitive awareness; performance in algebra; value of algebra; learning algebra

Introduction

In most tertiary mathematics curricula, Algebra is introduced as a first-year undergraduate course to serve as a foundation for studying advanced mathematical fields. This is often so because learning Algebra fosters critical thinking skills, problem-solving skills and logical reasoning (Wahyuni et al., 2022). These higher order thinking skills act as a conduit in academia and professions (Abidin et al., 2021; Tooher & Johnson, 2020). As a prerequisite for higher mathematics education, learning Algebra also enables undergraduates to develop cognition and self-regulatory learning strategies and attitudes needed for progression into diverse academic and career paths (Arnawa et al., 2019).

It is well-documented that attitudes and academic success of undergraduates in

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mathematics courses are related. Studies by Owu-Annan, Assuah & Akayuure (2022) and Cerbito (2020) suggest that there is a positive correlation between a favorable attitude and improved performance in mathematics. Conversely, there is consistent evidence linking negative attitudes to poor academic outcomes in Mathematics (Owu-Annan & Assuah, 2023; Hagan et al., 2020; Mazana et al., 2019). While the above evidence suggests an association between attitudes manifested by undergraduates and their learning successes in mathematics, not much is known in the area of undergraduate Algebra.

Aside attitude, there is a growing controversy regarding how undergraduates adjust in their learning strategies to ensure success. For instance, Blasiman, Dunlosky and Rawson (2017) raises concerns about how undergraduate apply metacognitive and self-regulation learning strategies such as setting specific learning goals, scheduling study sessions, monitoring progress, allocating dedicated time to meet deadlines, leveraging online resources, engaging in reflective practices, learning through collaboration and seeking help. Although less explored in the field of Algebra, it could be noted that undergraduate mathematics students are also challenged with similar metacognitive strategies in their learning or examinations.

It is well-recognised that as students transition from secondary to tertiary education, they tend to gain more responsibility for their learning decisions by utilising their metacognition and independent thinking strategies (Stanton, Sebesta & Dunlosky, 2021). In particular, many students tend rely on such passive learning strategies by sequentially reviewing study material rather than connecting concepts for deeper understanding. Some students also engage in certain metacognitive processes without a full grasp of their benefits (Karpicke et al., 2009). Additionally, students often plan their study schedules based on examination dates and deadlines rather than adopting strategic and proactive planning to ensure readiness (Hartwig & Dunlosky, 2012). Understanding and addressing these learning behaviours is crucial for improving the academic success of undergraduate in Algebra courses.

In Ghana, the transition to tertiary education poses significant challenges for students as they face increased responsibility and self-regulation in their learning. The difficulties that first-year undergraduates encounter while learning Algebra course, warrant an investigation to understand the correlation between their attitudes, metacognitive awareness, and their scores in Algebra. This study therefore examined the relationship between first year undergraduates' attitudes (self-confidence, enjoyment, motivation and value of algebra), metacognitive awareness and algebraic scores.

Literature Review

Algebra education and the attitudinal theory

Algebra education, as emphasised by Mathaba and Bayaga (2021), fosters logical and critical thinking skill which enables individuals to dissect problems methodically and formulate effective solutions. Such thinking skill extends beyond mathematics to providing valuable information on real-world situations and diverse disciplines. Mulungye et al. (2016) stress the lifelong importance of algebraic thinking skills and how such skills influence decision-making in areas like finances, science, engineering and technology. However, the acquisition of algebraic thinking skills may be contingent on students' mindset and attitudes towards learning the course.

In the mid-1950s, Albert Ellis introduced the ABC theory of attitudes, which posits that attitudes consist of three key elements: Affect, Behaviour, and Cognition. Affect refers to an individual's emotional response to an attitude

object, while Behaviour reflects their intentions or actions towards it. Cognition encompasses the beliefs and thoughts one holds about the attitude object.

Similarly, Ayob and Yasin (2017) identified three components of attitudes: Cognitive, Affective, and Behavioral. The Affective component involves feelings or emotions towards the object, the Behavioural component relates to readiness for action or actual responses, and the Cognitive component pertains to mental beliefs or evaluations.

In the context of mathematics, cognitive attitudes shape students' opinions and judgments. For instance, a positive cognitive attitude towards algebra may lead a student to perceive it as a valuable problem-solving tool, thus increasing their likelihood of success in learning algebra (Owu-Annan et al., 2022).

The affective component of attitudes in mathematics education influences students' engagement levels. Positive affective attitudes, characterised by feelings of excitement or confidence, are associated with greater enthusiasm and involvement in problem-solving activities (Agarwal & Malhotra, 2005).

Lastly, the behavioural component of attitudes is reflected in observable actions or responses towards the attitude object. For example, students may demonstrate enthusiasm or reluctance in participating in algebraic activities, which reflects their underlying attitudes (Jain, 2014). These overt behaviours are often more readily observable than the underlying cognitive and affective components.

Attitude in terms of self-confidence, enjoyment, motivation and perceived value

Self-confidence, enjoyment, motivation, and perceived value are commonly utilised as key aspects in research to measure attitudes towards a subject or domain particularly within the of undergraduate mathematics education (Tapia, 1996; Owu-Annan et al, 2022). Self-confidence in algebra, within the context of undergraduate mathematics education, encompasses students' perceptions of their own abilities and potential to learn and excel in algebraic concepts (Adelson & McCoach, 2011). Research by Hannula, Maijala, and Pehkonen (2004) underscores the significance of self-confidence as a determinant of students' learning outcomes in algebra, indicating its pivotal role in shaping academic performance.

Similarly, the enjoyment of algebra reflects the degree to which undergraduate mathematics students derive pleasure from engaging in and learning about algebraic concepts (Syyeda, 2016). This enjoyment directly influences students' behavioural and cognitive attitudes towards the subject, as heightened enjoyment correlates with increased participation in problem-solving activities, thereby enhancing learning outcomes and academic performance.

Motivation, a multifaceted aspect of human psychology and behaviour, profoundly impacts how first-year undergraduate mathematics students allocate their time, energy, and cognitive resources to algebraic tasks (Bakar, 2014). Students' motivation is evident in their choice of learning activities, the level of effort exerted, their persistence in tackling algebraic challenges, and their strategies for overcoming obstacles encountered during the learning process.

The value attributed to algebra by undergraduate mathematics students reflects their perceptions of its relevance and utility in both present-day contexts and future endeavours (Adelson & McCoach, 2011). Recognising the practical significance of algebraic skills motivates students to engage more deeply with the subject matter, invest time in practice and study, and ultimately strive for mastery (Syyeda, 2016).

In summary, the interplay of self-confidence, enjoyment, motivation, and perceived value collectively shapes undergraduate mathematics students' attitudes towards algebra and significantly influences their learning experiences and academic performance in the subject. Understanding and addressing these factors are essential for fostering a positive and conducive learning environment conducive to students' mathematical growth and achievement.

Metacognition in Mathematics Learning

Metacognition is the awareness that one has about his or her knowledge and the regulation of learning processes to meet the demands of a particular task (Siqueira,2020). Metacognitive awareness provides possible opportunities for understanding the difficulties first-year undergraduate mathematics education students face when attempting to learn algebra. Research in metacognitive awareness suggests that students must have metacognitive knowledge and awareness about their studies in order to implement them successfully (Raymond, 2019).

In authentic self-regulated learning, a dynamic and reciprocal relationship exists between metacognitive monitoring and control processes. Metacognition, encompassing self-regulation, involves self-reflection on advantages, disadvantages, and learning strategies (Pratiwi, 2019). In learning contexts with metacognition, students understand how to learn, recognise their capabilities, and employ effective learning strategies for optimal learning outcomes (Zulirfan et al., 2018).

By engaging in self-regulated learning, learners can assess their current knowledge against context-specific criteria to plan and implement effective study strategies (Morphew, Gladding & Mestre, 2020). Similarly, Sun and Chiou (2017) investigated the impact of comparison and game-challenge strategies on sixth graders' learning achievement, attitude, and meta-cognitive awareness in algebra variable learning. Using a 2x2 factorial design, the study revealed a significant interactive effect on students' learning achievement in algebra variables. Moreover, a significant interaction effect was observed in students' attitudes and meta-cognitive awareness toward algebra variable learning.

In 2016, Siew, Geofrey, and Lee conducted a study to explore the impact of the Dragon Box 12+ Android app on eighth-grade students' algebraic thinking and attitudes toward algebra. Utilising pretest and posttest assessments for algebraic thinking and a Fennema-Sherman questionnaire for attitude measurement, the results indicated significantly higher mean scores in both algebraic thinking and attitudes among students using DragonBox 12+ compared to the control group. This suggests the app's potential in supporting mathematics teachers with effective game-based learning for algebra instruction. Additionally, Alsaeed (2017) investigated middle school teachers' awareness of using the internet to teach and enhance students' algebra learning. The study, which employed interviews and questionnaires, revealed positive outcomes, with students benefiting from internet-based learning in algebra and expressing enjoyment in working with technology in the classroom.

In conclusion, research reviewed so far highlights the critical roles of attitude and metacognition in undergraduates' success in mathematics, especially as they independently navigate their studies. Despite its importance, there is limited studies particularly, on algebraic metacognition and student attitudes. This study aims to address this gap by examining how these factors impact learning outcomes in undergraduate algebra.

Methodology

Research design

Descriptive study design was employed in this study to gain a broader and more comprehensive understanding of the relationship among first year mathematics undergraduate students' attitudes towards Algebra, their metacognitive awareness and Algebra performance.

Participants and sampling technique

The study focused on first-year undergraduate mathematics education students at the University of Education, Winneba (UEW) in Ghana. This cohort consisted of 225 students, all of whom had previously studied Algebra either in senior high schools or teacher training colleges prior to their university enrollment. Upon joining the university, they attended four months of Algebra lectures, after which they undertook their first-semester examinations. Of these students, 180 agreed to participate and hence completed an online survey. This subset of students, with their prior exposure to Algebra and recent academic experiences, formed the basis of the study.

Instrumentation, validity and reliability

The study utilised two inventories and students' end-of-semester examination scores in algebra to gather data. The first inventory, adapted from Balcikanli (2011), consisted of six items designed to measure students' metacognitive awareness. These items were specifically selected from Balcikanli's inventory of metacognitive awareness for teachers. The second inventory, derived from Tapia (1996), included 20 items aimed at assessing students' attitudes towards algebra. These items were categorised into four dimensions: Self-confidence, Enjoyment of algebra, Motivation, and Value of algebra, with five items dedicated to each category. All items from both inventories were rated on a five-point Likert scale, ranging from "strongly disagree" to "strongly agree," and were administered via Google Forms.

Additionally, the students' performance, in respect of scores, in Algebra I (one of the courses offered by all Level 100 mathematics students in the Department of Mathematics Education) were obtained from the lecturer of the course in the department. The algebra examination comprised a multiple-choice section and a constructed-response section. The multiple-choice section of the examination comprised 20 items and the constructed-response section had four items in which students were required to answer a compulsory question and any other two questions. Both the multiple-choice and constructed-response items of the examination were aligned with the content of the first-year undergraduate mathematics education algebra course.

To ensure the validity and reliability of the instruments used in this study, they underwent rigorous analysis. Experts and research fellows from UEW reviewed the instruments for face and content validity, providing feedback that was incorporated to enhance their usefulness and consistency. The instruments were also pretested, and the reliability coefficients, detailed in Table 1, indicates high reliability. According to Sekeran (2013), reliability values below 0.60

Table 1 Cronbach alpha reliability coefficients of inventories used for the study

Construct	Number of items	Cronbach Alpha reliability coefficient
Attitude	20	0.849
Metacognitive awareness	6	0.786

are considered poor, those around 0.70 are acceptable, and values above 0.80 are deemed high. The high reliability coefficients suggest that the instruments were well-suited for this study's data collection.

Data collection and analysis

The questionnaire items were put into Google Forms and distributed to undergraduate mathematics education students via multiple online platforms. Prior to distribution, the purpose of the study was clearly explained to potential participants during a face-to-face lecture. Students were made aware that participation in the study was voluntary and only those who consented responded to the questionnaire. Of the 255 first year students in the Department of Mathematics Education, 180 completed the inventories, resulting in a response rate of 70.6%.

For data analysis, the responses were initially edited and coded, with each item serially labeled to facilitate error detection and easy reference. The data was then scrutinized for outliers and missing values through frequency checks. Negative statements within the variables were reverse coded to maintain consistency in data interpretation. Statistical analysis was conducted using SPSS software, version 26, which provided descriptive statistics, and computed correlation and regression coefficients.

The analysis aligned students' end-of-first-semester algebra scores with their responses on the inventories to examine the relationships between academic performance, attitudes, and metacognitive awareness. To avoid bias interpretation, the key assumptions necessary for regression analysis, such as normality, homoscedasticity, linearity, independence, were tested and found not to have been violated.

Results

The students' algebra performance, in respect of scores, in the algebra examination was first determined. This was followed by exploring the influence of the first-year undergraduate mathematics education students' algebra performance on their attitudes (i.e., self-confidence, enjoyment, motivation and value of algebra) and metacognitive awareness.

Students' performance, in respect of scores, in the Algebra examination

Table 2 presents the descriptive statistics of scores obtained on the algebra examination by the 180 undergraduate mathematics education students who participated in the study. The overall mean score for the algebra test (M = 51.62, SD = 14.96) suggests that participants performed at an average level. The standard deviation indicates a moderate spread of scores around the mean. The algebra scores ranged from 12 to 89, with no participants scoring either a zero or the full mark.

Table 2 Descriptive statistics of scores obtained on the algebra examination by the students who participated in the study

	N	Min	Max	Mean	Std. Dev.
Algebra scores	180	12	89	51.62	14.96

Attitudes towards algebra and their Metacognitive awareness in it

As indicated above, four subscales of attitude were rated by the students in the questionnaire comprising self-confidence, enjoyment in doing algebra, motivation and value of algebra. Table 3 shows the descriptive statistics of the students' rating of their agreement to statements about their self-confidence and enjoyment in doing algebra.

From Table 3, in terms of agreement to items on self-confidence, the students' highest average rating in was on "I have a lot of self-confidence when it comes to algebra" (M = 4.13, SD = .85) and least was "I feel a sense of insecurity when attempting algebra" (M = 2.69, SD = 1.23). These are statements that 83.3% and 46.1% of the students respectively agreed upon. The overall mean rating of self-

Table 3 Descriptive statistics of students' rating of their agreement to statements about their self-confidence and enjoyment in doing algebra

Statements	SD	D	NS	A	SA	M	Std. Div.
Self-confidence							
a) I have a lot of self-confidence when it comes to algebra	2 (1.1)	7(3.9)	21(11.7)	86(47.8)	64(35.5)	4.13	.85
b) I am comfortable answering questions in algebra class	6(3.3)	25(13.9)	37(20.6)	77(42.8)	35(19.4)	3.61	1.05
c) I learn algebra easily	7(3.9)	34(18.9)	37(20.6)	72(40.0)	30(16.6)	3.47	1.10
d) I like to solve new problems in algebra	3(1.7)	10(5.6)	26(14.4)	96(53.3)	45(25.0)	3.94	.88
e) I feel a sense of insecurity when attempting algebra	10(5.6)	48(26.7)	38(21.1)	45(25.0)	39(21.6)	2.69	1.23
Overall mean self-confidence						*3.57*	*.55*
Enjoyment of Algebra							
a) Algebra does not scare me at all	4(2.2)	22(12.2)	34(18.9)	77(42.8)	43(23.9)	3.74	1.03
b) Algebra makes me feel uncomfortable	5(2.8)	7(3.9)	31(17.2)	72(40.0)	65(36.1)	1.94	.97
c) I am always confused in my algebra class	7(3.9)	22(12.2)	54(30.0)	58(32.2)	39(21.7)	4.28	.83
d) I usually enjoyed studying algebra in school	3(1.7)	5(2.8)	10(5.5)	82(45.6)	80(44.4)	3.99	1.04
e) I am happier in algebra class than in any other class	8(4.4)	10(5.6)	19(10.6)	82(45.6)	61(33.8)	4.16	.90
Overall mean enjoyment						*3.63*	*.58*

confidence M = 3.57, SD = .55) show that majority of the students were undecided about their self-confidence towards the algebra course.

On enjoyment, students rated "Algebra makes me feel uncomfortable" (M = 1.94, SD = .94) the least. About 36.1% of the students strongly agreed to it. The highest rating was "I am always confused in my algebra class" (M= 4.28, SD=.83). The overall mean ratings of the items on enjoyment clustered around (M=3.63, SD =.58). This indicates that majority of the students were uncertain about their enjoyment of the algebra course. Tables 4 shows the descriptive statistics of the students' rating of their agreement to statements about their motivation to learn algebra.

On motivation items, the statement "I want to develop my algebra skills very well" recorded the highest rating of agreement where about 73% strongly agreed to it (M = 4.08, SD =.87). The least rating of agreement was "I am able to solve algebra problems without too much difficulty" (M=3.96, SD=.90). The overall mean rating of motivation towards learning algebra was (M=4.36, SD = .66). This shows that majority of the students have homogeneous views about their motivation towards learning algebra. Tables 5 shows the descriptive statistics of the students' rating of their agreement to statements about their value of algebra.

Table 4 Descriptive statistics of students' rating of their agreement to statements about their motivation to learn algebra

	SD	D	NS	A	SA	M	Std. Div.
Motivation statements							
a) I get a great deal of satisfaction out of solving algebra problem	3(1.7)	9(5.0)	16(8.9)	80(44.4)	72(40.0)	4.64	.72
b) I want to develop my algebra skills very well	2(1.1)	3(1.7)	5(2.8)	38(21.1)	132(73.3)	4.08	.87
c) I am able to solve algebra problems without too much difficulty	7(3.9)	31(17.2)	56(31.1)	67(37.2)	19(10.6)	3.96	.90
d) I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in algebra.	3(1.7)	6(3.4)	26(14.4)	83(46.1)	62(34.4)	4.50	.81
e) I am willing to take more than the required amount of algebra given by my lecturer	3(1.7)	10(5.6)	26(14.4)	94(52.2)	47(26.1)	4.62	.74
Overall mean motivation						*4.36*	*.66*

Table 5 Descriptive statistics of students' rating of their agreement to statements about their value of algebra

	SD	D	NS	A	SA	M	Std. Div.
Value of algebra statements							
a) Algebra is a very worthwhile and necessary course	3(1.7)	3(1.7)	9(5.0)	51(28.3)	114(63.3)	4.69	.69
b) Algebra helps develop the mind and teaches a person to think	2(1.1)	3(1.7)	7(3.9)	37(20.5)	131(72.8)	4.53	.81
c) Algebra is important in everyday life	2(1.1)	2(1.1)	6(3.3)	29(16.1)	141(78.4)	4.21	.96
d) Algebra is one of the most important courses for math students to study	3(1.7)	4(2.2)	7(3.9)	46(25.6)	120(66.6)	2.44	1.08
e) I can think of many ways that I use algebra outside of school	4(2.2)	7(3.9)	23(12.8)	60(33.3)	86(47.8)	3.33	1.01
Overall mean value of algebra						*3.84*	*.55*

Finally, on the value of algebra, the item on "Algebra is important in everyday life" was the highest rating where about 78% of the students strongly agree to it (M=4.21, SD=.96). The overall mean rating for the value of algebra was (M=3.84, SD=.55). This shows that majority of the students were not certain about the value of studying the algebra course. Table 6 shows the descriptive statistics of the students' rating of their agreement to statements about metacognitive awareness in algebra.

As shown in Table 6, students mean rating of metacognitive awareness items ranged from 2.57 to 3.95, that is they are either largely disagreeing to agreeing with some undecided about their opinions. The highest mean rating was "I motivate myself to learn when I really want to learn algebra" (M=3.97, SD=. 89) corresponding to 39.4% of the students. The least mean rating "I work extra problems in my algebra course in addition to the assigned ones to master the course content" (M=2.57, SD =.1.02).

Table 6 Descriptive statistics of students' rating of their agreement to statements about their metacognitive awareness in algebra

	SD	D	NS	A	SA	M	Std. Div.
Statements about metacognitive awareness							
a) I keep a high standard for my learning in algebra courses	38(21.1)	59(32.8)	37(20.6)	34(18.9)	12(6.7)	3.93	.90
b) I choose the location where I study algebra courses to avoid too much distraction	17(9.4)	32(17.8)	56(31.1)	59(32.8)	16(8.9)	3.95	.89
c) I work extra problems in my algebra course in addition to the assigned ones to master the course content	11(6.1)	28(15.6)	62(34.4)	63(35.0)	16(8.9)	2.57	1.21
d) I ask myself periodically if I meet my learning goals while I am learning algebra	10(5.6)	28(15.6)	55(30.6)	70(38.9)	17(9.4)	3.14	1.11
e) I motivate myself to learn when I really need to learn algebra	2(1.1)	23(12.8)	64(35.6)	71(39.4)	20(11.1)	3.25	1.02
f) I pace myself while I am learning algebra in order to have enough time.	25(13.9)	43(23.9)	43(23.9)	56(31.1)	13(7.2)	3.31	1.03
Overall mean metacognitive awareness						*3.44*	*.59*

The overall mean rating for all the metacognitive awareness items (M=3.44, SD =.59) indicates that majority of the students were uncertain about their knowledge of cognition and how they should regulate their cognition towards learning algebra.

Attitudes, metacognitive awareness and algebra scores

Second, the study sought to determine the relationships among first year undergraduate mathematics education students' attitudes towards learning algebra (self-confidence, enjoyment, motivation and value of algebra),

metacognitive awareness and algebra scores. The Pearson product-moment correlation was used to test for the degree of relationships at .05 significance level. The result is presented in Table 7.

Table 7 Results of Pearson correlation between attitude and metacognitive awareness variables and the students' algebra scores

Attitude Variables	Statistics	Algebra Scores
Self-Confidence	Pearson Correlation	-.291**
	Sig. (2-tailed)	.000
Enjoyment	Pearson Correlation	-.175*
	Sig. (2-tailed)	.019
Motivation	Pearson Correlation	.056
	Sig. (2-tailed)	.453
Value of algebra	Pearson Correlation	-.060
	Sig. (2-tailed)	.421
Metacognitive awareness	Pearson Correlation	.180*
	Sig. (2-tailed)	.016
	N	180

Table 7 shows weak negative significant correlation between self-confidence and Algebra scores [r = -.29, n= 180, p < .05] signifying that the students' self-confidence was negatively linked to algebra scores. Again, there were weak, negative but significant correlation between enjoyment and Algebra scores [r = -.1.8, n=180, p < .05]. This shows that the students' enjoyment in learning Algebra course has reverse association with Algebra score. On the contrary, motivation and algebra scores [r = .06, n =180, p > .05 was not significant correlation. Furthermore, there was an insignificant correlation between students' value of algebra and their Algebra scores [r = - .06, n =180, p > .05]. In terms of metacognition, there was positive significant correlation between metacognitive awareness and algebra scores [r = .18, n= 180, p < .05] signifying that the students' high metacognitive awareness in algebra course was associated with high level of algebra scores.

Attitudes and metacognitive awareness as predictors of algebraic scores

Third, the study sought to examine the predictive power of attitudes towards algebra (in terms of self-confidence, enjoyment, motivation and value of algebra) and metacognitive awareness on the algebra scores of first year undergraduate mathematics education students. Simple linear regression was performed at .05 significance level. Table 8 presents the results of the regression model summary.

From Table 8, the standard regression model summary shows the value of the multiple correlation coefficient (R= .385) between the predictor variables and algebra scores. The R square ($R^2 = .148$) which is the coefficient of determination shows that attitude towards algebra (self-confidence, enjoyment, motivation and value of algebra), and metacognitive awareness accounted for 14.8% of variability in the students' algebra scores. The Durbin Watson value of 1.891 indicates

Table 8 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin Watson
1	.385	.148	.124	14.002	1.891

negligible level of positive autocorrelation, implying that the independence of the residuals' assumption is largely met. Aside independence of the residuals, assumptions of normality of residuals and linearity were examined with no evidence of violations (see Figure 1).

Figure 1 P-P Plots of Regression standardized residuals

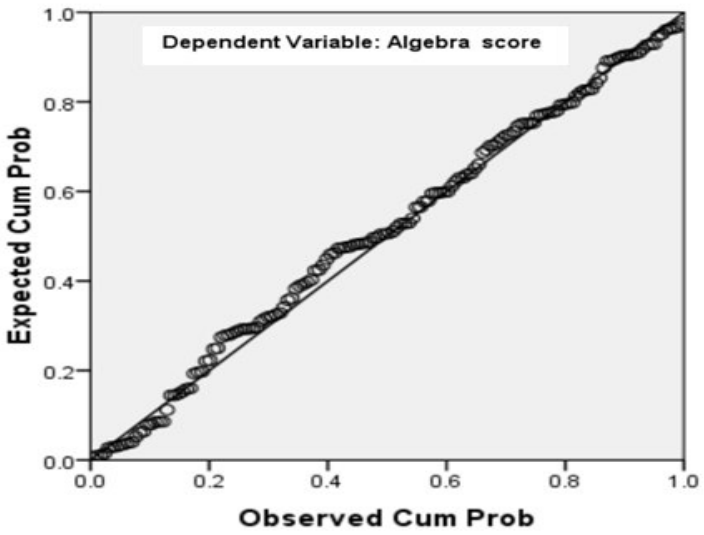

Table 9 presents the results of the analysis of variance (ANOVA) results for the overall regression model (Table 8).

Table 9 ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5945.311	5	1189.062	6.065	.000
Residual	34113.239	174	196.053		
Total	40058.550	179			

a. Predictors: (Constant), Attitude (self-confidence, motivation, enjoyment, value) and metacognitive awareness
b. Dependent Variable: Algebra scores

The results from the ANOVA table, F (5, 179) = 6.065, P < 0.05) indicates that the overall regression model was significant. This means that the predictor variables (attitude and metacognitive awareness) have significantly relationship with algebra scores. These relationships are presented in Table 10.

The table shows that among the four sub-scales of students' attitude towards learning algebra, self-confidence (p < .001) and enjoyment (p < .037) significantly predict algebra scores of first year mathematics undergraduate students. The coefficients of self-confidence (-3.238) and enjoyment (-1.654) however show they are contributing negatively to the algebra scores of the students. On the other hand, motivation (p>.05) and value p>.05) of algebra did not significantly predict first year mathematics education students' algebra scores. Finally, metacognitive awareness (p < 0.05) significantly predict algebra scores of first year mathematics undergraduate students. Its estimated coefficient (5.107) shows that an improvement in students' metacognitive awareness leads to a likely improvement (5.107 increase) in their algebra scores.

Table 10 Coefficients

Model	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	45.132	7.378		6.117	.000
Attitude components:					
Enjoyment	-1.654	.786	-.149	-2.105	.037
Motivation	.612	.644	.067	.951	.343
Value of algebra	.428	.797	.040	.537	.592
Self-Confidence	-3.238	.829	-.295	-3.904	.000
Metacognitive awareness	5.107	1.830	.196	2.790	.006

[a].Dependent Variable: Algebra scores

Discussion of findings

The focus of the study was to examine the relationships between attitudes towards learning algebra, metacognitive awareness, and algebra performance among first-year university students in Ghana. The study found that the majority of students were undecided about their self-confidence and enjoyment of the algebra course. This uncertainty could be indicative of broader issues within the educational environment, such as teaching methods, course content and/or assessment strategies that might not fully engage or inspire confidence in students. Self-confidence and enjoyment in mathematics are often linked to greater engagement and better outcomes in learning (Owu-Annan, Assuah & Akayuure, 2022; Dono & Mangila, 2021). Syyeda (2016) acknowledged that students' enjoyment while learning can influence their behaviour or cognition. The PISA 2012 results published by OECD (2013) also noted that students may learn algebra because they find it enjoyable and interesting. Therefore, the lack of clear positive or negative feelings in this present study suggest the need for interventions that explicitly aim to increase the first year students' confidence and enjoyment in the course. These may include exposure to different types of algebraic problems and provision of supportive learning environments including digital spaces, where students could feel safe to make mistakes, ask questions and obtain tailor-made answers. A more in-depth investigation using qualitative approaches may also be require to help clarify the nature and quality of confidence and enjoyment expressed by the students.

On motivation and value laden, the majority of the students appeared uniform in their motivation towards learning algebra but uncertain about the value of the algebra course. This suggests that while students are willing to engage with the course, they may not fully appreciate or understand how algebra fits into their overall mathematics education and professional goals as future teachers. This finding points to a potential disconnect between students' recognition of the immediate benefits of learning algebra and the long-term utility of the course (Arhin & Yanney, 2020). Guy, et al. (2015) asserted that value of algebra is a positive predictor of success. The uncertainty expressed by the students in this study therefore suggests the need to help bridge the gap by linking the curriculum relevance with real-world applications of algebra and future career paths of the students.

For metacognitive awareness, most students were uncertain about their knowledge of cognition and their ability to regulate it. Blasiman, Dunlosky and Rawson (2017) argued that undergraduates need to apply metacognitive and self-regulation learning including goal setting, study scheduling, reflective practice and help seeking, to meet their learning demands. Raymond (2019) added that students need to have metacognitive knowledge and awareness about their studies to be successful. This is particularly important in subjects like algebra which require significant abstract thinking and problem-solving skills. Hence, the present finding suggests the need to foster these metacognitive aspects through specific training or orientations to help students become more effective learners, not just in algebra but across other mathematics subjects.

In terms of correlations with algebra performance, negative associations were found between self-confidence and enjoyment with algebra scores. This is quite intriguing since normally, one would expect positive attitudes to correlate with higher performance (Mazana et al, 2019). The reverse associations observed might indicate that students who are overconfident or who superficially enjoy the course without deeper engagement might not perform well. This suggests the need for deeper diagnostic assessments to understand the quality of students' confidence and enjoyment. On the contrary, the study found positive correlation between metacognitive awareness and algebra scores. This tends to reinforce the importance of metacognitive skills in academic success and calls for the need devise strategies that would help foster students' awareness of their cognitive and self-regulatory strategies in algebra.

On the predictive power of attitudes and metacognition, a significantly negative impact of self-confidence and enjoyment as well as metacognitive awareness on algebra scores were found. This finding is in line with Sun and Chiou (2017) who reported significant relationship between meta-cognitive awareness of algebra and algebra performance. This suggests that these are critical areas which need attention. For example, instructional strategies focusing on authentic confidence building and intrinsic enjoyment might be needed rather than those that only superficially address attitudes. The positive prediction of algebra scores by metacognitive awareness in particular, suggests that interventions aimed at enhancing these skills could be particularly beneficial.

Implications

Findings in the study underscore the complex interplay between attitudes, metacognitive awareness, and performance in algebra. This call for instructional interventions which are multifaceted and aimed at addressing both emotional (confidence and enjoyment) and cognitive (value and metacognition) components of first year mathematics students to foster a more conducive learning environment. This could include strategies such as:

- Implementing pedagogical approaches that build real confidence and understanding.
- Using teaching methods that make learning algebra enjoyable and engaging.
- Linking algebra content to real-world applications to enhance perceived value.
- Training students in metacognitive strategies to improve their self-regulation and awareness.

Specifically, it is suggested that algebra lecturers should incorporate orientations into their teaching practices to enable first year students enhance their awareness of how to learn algebra. Also, there is the need for

algebra lecturers to motivate, and organise workshops and seminars for first year students' to become aware of their metacognition in algebra for maximum performance in algebra.

Limitations

Some potential limitations which may affect the interpretation and generalizability of the findings need to be highlighted. These include issues of sample specificity, dependence on self-reported data, potential for unmeasured confounding variables and the complexity in constructing attitude and metacognition. For example, the study focused on first year students who often have unique challenges and perspectives that do not necessarily represent those of more advanced students. The reliance on single point data also might not have accounted for changes over time, which are often influenced by further education, personal experiences or maturation. Furthermore, the use of self-reported instruments for measuring attitudes and metacognitive awareness can introduce biases. Each of these limitations offers a pathway for future research, such as through longitudinal studies, expanded and more diverse samples, inclusion of additional variables or instrument triangulations. Addressing these limitations in subsequent studies could provide another layer that may highlight the dynamics between student attitudes, metacognitive awareness, and academic performance in mathematics.

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